

TITLE

FIELD EMISSION DISPLAY CATHODE (FED) PLATE WITH AN INTERNAL  
VIA AND THE FABRICATION METHOD FOR THE CATHODE PLATE

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BACKGROUND OF THE INVENTION

**Field of the Invention:**

The invention relates to an FED structure,  
10 particularly to an FED cathode plate with an internal via  
and the fabrication method for the cathode plate, which  
uses the vaporization to form the internal via such that  
the cathode sealing area of FED appears homogeneous,  
thereby increasing the yield.

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**Description of the Related Art:**

Fig. 1 is a schematic diagram of a typical FED cathode  
plate. In Fig. 1, the FED cathode plate is generally  
formed by layers successively deposited onto a substrate  
10 10. The layers include a resistive layer 11, a cathode  
conductor layer 13, a microtip 2, a microtip cavity 3, a  
microtip hole 4, a gate line 5, a contact 7, a dielectric  
layer 16, a tape line 18, a seal 8, and an anode plate 9.

As shown in Fig. 1, in such a structure, the FED emits  
25 electrons induced by the electrical field of the gate line  
5 from the microtip 2 through the hole 4. The emitted  
electrons are conducted and sped up by the anode plate 9  
and impact the fluorescent powder (not shown) distributed  
on the surface of the anode plate 9. Thus, fluorescent  
30 light is emitted. The light can pass through the anode 9  
and present on the back of the anode 9 (i.e. display plate  
(not shown)) to display an image. The operation principle  
of the FED is generally similar to a Cathode Ray Tube

(CRT), except that the FED can be produced in a thin flat panel display.

A typical FED cathode plate is prepared through 6 photolithography, 6 etchings, and 6 thin film processes. Like numbers refer to like components in all drawings. Fig. 2 is a diagram of the fabrication steps of Fig. 1. In Fig. 2, the steps include deposition, etching, evaporation, and lift-off. As shown in Fig. 2, the FED cathode plate is successively deposited onto a substrate 10 to constitute the layers having a microtip hole 4 on the top, as shown in Fig. 2a. As shown in Fig. 2b, the dielectric layer 16 is etched to form the microtip cavity 3 about 2  $\mu\text{m}$  wide, using dry and wet etching. As shown in Fig. 2c, graze evaporation is used on the plate with a slope of 20° to form an aluminium conductor layer 19. As shown in Fig. 2d, the evaporation is used in the plate with a vertical position like the arrow shown to form the microtip 2 within the microtip cavity 3. As shown in Fig. 2e, the phosphoric acid solution is used to lift off excessive deposition, including the layer 19, and only leave the microtip 2 within the cavity 3. Thus, a typical cathode plate is completed. Further, a glass frit is used to join the cathode plate to the anode plate 9 which are then sealed to form an electrode in vacuum.

The sealing area of the electrode is located around the light-emitting region of the display (Fig. 1). The sealing prevents outside air from diffusing into the display, thus ensuring the integrity of the display's vacuum. The glass frit, however, has a tendency toward corruption. Accordingly, chromium (Cr) is used in the passages (i.e. tape line 18) of the two lateral edges through which the glass frit passes. Although the chromium can prevent corruption from the glass frit, the adhesion difference between chromium and the  $\text{SiO}_2$  composing the dielectric

layer 16 can easily cause splits in the edge of the structure during durability testing of the product, compromising the vacuum inside the display. In such cases, the display provides uneven illumination and a friable structure in the sealed area, thus reducing the yield. As well, the hole 4 is small, about 1  $\mu\text{m}$ , and the efficient depth of focus (DOF) for photolithography is low, so that exposure uniformity may be insufficient, further causing stepper shots' marks, reducing the yield of the cathode plate.

#### SUMMARY O F THE INVENTION

Accordingly, an object of the invention is to provide an FED cathode plate with an internal via, which prevents diffusion of outside air from corrupting the vacuum inside, thus increasing the evenness and durability of the FED frame.

Another object of the invention is to provide a fabrication method for the FED cathode plate with an internal via, which uses the internal via and improves the processes, thereby reducing the cycle, the limit, and the cost in the processes.

The invention is an FED cathode plate with an internal via and the fabrication method for the FED cathode plate. The FED cathode plate with an internal via includes: a substrate; a resistive layer with a cathode conductor deposited over the substrate; a tape line located on the substrate and kept separate from the resistive layer; a first dielectric layer, located on the resistive layer and part of the tape line and having a microtip cavity to accommodate a microtip; a first gate line, located over the first dielectric layer and having a respective microtip hole of the microtip; an internal via, located on the tape line and abutted against the first dielectric layer and the

gate line; a second dielectric layer, located on the tape line and abutted against the internal via, thereby connecting to an anode by an adhesive; a second gate line, located on the second dielectric layer and abutted against the internal via; a metal layer covering the first gate line, the internal via, and the second gate line; and a contact, located on the tape line and connected adjacent to the second dielectric layer, thereby electrically connecting a lead to the outside. The fabrication method includes the following steps: depositing an FED cathode structure from bottom to top including a substrate, a resistive layer, a dielectric layer, and a gate line; dry etching the cathode structure to form a cathode plate with the hole and cavity of a microtip, an internal via, and a contact; sloping the plate to a predetermined angle to form a metal layer by evaporation; forming a microtip within the microtip cavity by vertical layer evaporation; and lifting off the excessive deposition on the surface of the plate by immersing the plate in a chemical solution.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The aforementioned objects, features and advantages of this invention will become apparent by referring to the following detailed description of a preferred embodiment with reference to the accompanying drawings, wherein:

Fig. 1 is a schematic diagram of a typical FED cathode plate;

Fig. 2 is a diagram of the fabrication steps of Fig. 1;

Fig. 3 is a schematic diagram of an FED cathode plate of the invention;

Fig. 4 is a diagram of the fabrication steps of Fig. 3; and

Fig. 5 is a comparison table of the fabrication steps of Figs. 2 and 4.

### DETAILED DESCRIPTION OF THE INVENTION

Fig. 3 is a schematic diagram of an FED cathode plate according to the invention. In Fig. 3, in addition to the typical FED structure, the structure also includes an internal via 6; a second dielectric layer 16b, a second gate line 5b, and a metal layer 12 covering the gate lines 5a, 5b and the internal via 6.

As shown in Fig. 3, the FED cathode plate with the internal via has a substrate 10 as the base of deposition. The material of the substrate 10 is glass. The resistive layer 11, a doped layer with a plurality of cathode conductors 13, is implemented over the substrate 10 to prevent a microtip 2 from being formed from excessive current. The material for the cathode conductors is niobium (Nb). The cathode conductors 13 are etched based on a column pattern to create a column line surrounding the cathode conductors 13. At the same time, the tape line 18 is formed on the substrate 10 maintaining a distance from the resistive layer 11. The tape line 18 is chromium (Cr). The tape line 18 is a thin film deposited along with the path from gate lines 5a and 5b, through a contact 7, bond wiring to a metal pad (not shown) outside. Next, the cathode is joined and sealed to the anode 9 with an adhesive 8, e.g. glass frit, thereby producing an electrode. The electrode interacts with the outside through the thin film 18. The first dielectric layer 16a formed of SiO<sub>2</sub> is located on the resistive layer 11 and part of the tape line 18 and has microtip cavities 3 to accommodate microtips 2. Dry etching the first dielectric layer 16a forms the cavity 3, about 2  $\mu$ m wide. The first dielectric layer 16a acts as an insulator. The first gate line 5a is located on the first dielectric layer 16a in order to use the first dielectric layer 16a to prevent the first gate line 5a from directly contacting the cathode

conductors 13. The first gate line 5a has a respective  
hole 4 located at the microtip 2. The hole 4 is deposited  
to be a diameter about 1.6  $\mu\text{m}$  wide. The internal via 6 is  
located on the tape line 18 and abutted against the first  
5 dielectric layer 16a and the gate line 5a. The internal  
via 6 is formed by dry etching. The second dielectric  
layer 16b is located on the tape line and abutted against  
the internal via 6. The first dielectric layer 16a and the  
second dielectric layer 16b have the same height and is Nb.  
10 The adhesive 8, for example, glass frit, is used to connect  
the second dielectric layer 16b of the cathode to an anode  
9. The second gate line 5b is located on the second  
dielectric layer 16b and abutted against the internal via  
6. The first gate line 5a is the same height as the second  
15 gate line. The metal layer is covered over the first gate  
line 5a, the internal via 6, and the metal layer 12 of the  
second gate line 5b. The metal layer 12 is about 2000Å and  
is formed of niobium (Nb). The contact 7 is located on the  
tape line 18 and connected adjacent to the second  
20 dielectric layer 16b, thereby electrically connecting a  
lead (not shown) to the outside through the internal via 6  
and the tape line 18.

When the adhesive (glass frit) 8 combines and seals  
with the anode 9, because the adhesive 8 erodes the Nb-  
25 including metal layer 12 on the second gate line 5b, a  
separate distance between the adhesive 8 and the metal 12  
is necessary, as shown in Fig. 3.

Fig. 4 is a diagram of the fabrication steps of Fig. 3.  
In Fig. 4, The fabrication method includes the steps:  
30 depositing an FED cathode structure (S41); dry etching the  
cathode structure to form a cathode plate (S42);  
evaporation the plate with a predetermined slope angle  
(S43); forming a microtip by vertical layer evaporation

(S44); and lifting off the excessive deposition by a solution (S45).

As shown in Fig. 4, in steps S41 and S42, the detail is shown in Fig. 5 that layers except for the substrate 10 are in the comparison table. As shown in Fig. 5, for the novel part concurrently referring to Fig. 3, the first layer is an Nb-including metal layer, deposited to form the column line 15 and the tape line 18. The second layer is the doped-silicon resistive layer 11 having the resistance function. The third layer is etched to form the microtip cavity 3, the internal via 6, and contact 7. The fourth layer is gate lines 5a and 5b. Thus, the invention deposits an FED cathode structure from bottom to top including a substrate, a resistive layer, a dielectric layer and a gate line. Also, the invention uses dry etching in the cathode structure to form a cathode plate with the hole and cavity of a microtip, an internal via, and a contact. The microtip is molybdenum. In step S43, the plate is sloped to a predetermined angle in order to form a metal layer by evaporation. The predetermined angle is preferably between 10 and 30 degrees. The material for evaporation to form the metal layer is Nb, compared to Al in the prior art. In step S44, the plate is recovered in a horizontal direction with the face to be deposited downward, thereby forming a microtip 2 within the microtip cavity 3. In step S45, excessive deposition on the surface of the plate is removed by solution, e.g. phosphoric acid and the Nb-including metal layer 12 and the microtip 2 are retained. The completed cathode plate is joined and sealed with the anode 9 by adhesive 8, e.g. glass frit. An FED is thus completed.

The invention, other than the 6 photolithography, 6 etchings, and 6 film processes in the prior art (see the original part of Fig. 5), only applies 4 photolithography, 4 etchings, and 5 film processes (the four layers of Fig. 5 +

substrate), when using the selected metal material. Therefore, required processes are reduced by about 1/3 from the prior art, reducing fabrication costs and cycle times, thereby reducing the likelihood of defect occurring. In the new process, the invention replaces the original tape line and dielectric layer (both in contact with the sealing area) with a single dielectric layer 16 (including 16a and 16b). Also, the internal via 6 connecting the gate line 5 (including 5a and 5b) to the metal line (not shown) of the sealing area of the plate edge is concurrently finished in the process of forming the microtip. Thus, the sealed interface of the dielectric layer 16 (for example, SiO<sub>2</sub>) only exists with uniform adhesion on the surfaces of the two-side sealing areas of the cathode surface, so that splits around the sealed area of the FED edge are prevented. The inner FED maintains its high vacuum state. Moreover, the invention keeps the microtip cavity the same size as the prior art but increases the size of the microtip hole in deed such that the DOF of its photolithogpahy is increased, reducing the stepper's shot mark caused by defocus.

Although the present invention has been described in its preferred embodiment, it is not intended to limit the invention to the precise embodiment disclosed herein. Those who are skilled in this technology can still make various alterations and modifications without departing from the scope and spirit of this invention. Therefore, the scope of the present invention shall be defined and protected by the following claims and their equivalents.